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INSULATING ARRANGEMENT FOR THE INNER INSULATION OF AN AIRCRAFT

The invention relates to an insulating arrangement for the inner insulation of an air vehicle according to the preamble of the claim 1.

It is known that the primary insulation located on the structure side for insulation systems presently used in aircraft construction essentially consists of an insulation base material and a film covering or encasing this insulation. The core material of the insulation system is protected against water entry with the conventionally utilized films. Moreover, the film covering or casing serves for the securing of the partially bulky or flossy insulation material. Generally, this casing or covering is dimensioned in such a manner so that it has lowest possible weight portions. In this context it can be determined, that due to the relatively thin film, upon the occurrence of water vapor diffusion through the film wall, the water vapor penetrates into the film-covered insulation packet. Thereby, the water vapor partially condenses out in the insulation packet. Moreover, diffused liquid particles (water) always repeatedly enter into the insulation packet through unsealed or leaky areas in the insulation packet or in the film covering. The condensation in the insulation packet leads to the result that a collecting of the liquid particles (of the water) occurs in the insulation

material, which may only be removed by additional drying efforts. This fact also has a very unpleasant effect, because the insulation system gains in weight due to the water accumulation(s) and thereby leads to an unnecessary increase of the weight of an  
5 aircraft.

As a result of the above, the invention is based on the object, to embody an insulation arrangement of the above mentioned type so that nearly no humid or moist air or other moist gas or water (vapor) particles will penetrate into a film-covered insulation packet, by means of suitable measures (and air guidances), while oppositely (in connection with an accumulation that has occurred in that manner), the accumulated moisture shall quickly escape without hindrance from the insulation packet.  
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This object is achieved by the measures defined in the claim 1. Advantageous embodiments of these measures are defined in the further claims.  
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The invention is described in greater detail in an example embodiment with reference to the accompanying drawings. It is shown by:  
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Fig. 3: the insulation arrangement according to Fig. 2 with the film covering consisting of a film.

In the Fig. 1, a conventionally utilized insulation arrangement for an aircraft is illustrated, which one installs in a known manner within an interspace (hollow space) which is bounded by

the inner region A and the structure region B of the aircraft. In practice, the interspace 7 is formed by the metal outer skin 6 (allocated to the structure region B) and an inner trim component 12, for example a plate-like cabin trim panel arranged at a spacing from the outer skin 6. In this context, the inner trim component 12 largely follows the curvature of the outer skin 6, whereby a vertical position of both means is selected in the Figs. 1 and 2. The inner trim component 12 is provided with machined-in slits or (other) holes or penetrations at certain locations, through which (generally) relatively warm (cabin) air 9, which comprises a relatively high moisture or humidity content, penetrates into the interspace. The actual insulation arrangement is made up of an insulation packet 1 and a conventional film covering (film 4) of synthetic plastic, which encases or covers the above mentioned bulky or flossy insulation material, or insulation material consisting of a foam, (of the insulation packet 1) for the purpose of securing the same. An air gap s is formed between the insulation packet and the outer skin 6.

In the conventionally utilized insulation arrangement of known insulation systems, films 4 are used, which largely prevent a liquid water entry (entry of water, moist or humid air or other moisture), yet are not (water) vapor tight due to their low density or tightness or due to the low diffusion resistance coefficient of the film covering. This circumstance has especially hindering effects on the film region or area directed toward the warmer cabin side of an aircraft. Since the forward penetration of the relatively warm air 9 (cabin air) through the

slits and cut-out notches of the inner trim component 12 (cabin trim paneling) continues to the surface of the film 4, moreover, the air 9 loaded with high air moisture or humidity can get into the insulation packet 1 through the film wall by an expected water vapor diffusion process. Since during the flight phase of the aircraft (predominantly in cruise flight) a strong cooling of the outer skin 6 to approximately -50°C (minus fifty degrees Celsius) will occur, it cannot be avoided, that the moisture contained in the water vapor (due to falling below the dew point) condenses out. The result will be a collecting or accumulating of moisture or ice in the insulation packet 1. During the landing and ground operation phase of the aircraft, the temperature of the outer skin 6 will increase. During this phase, the ice will correspondingly become water. The water, which is located in the insulation packet 1, will however only be able to leave or escape from the insulation packet 1 through larger (micro-porous) openings (not shown) in the film wall. It is, however, disadvantageous, that therefore the possibility also exists, that water will once again enter into the insulation packet 1 through these film openings. The release of water through the film wall in the form of water vapor is, however, only possible during a limited time, since (generally for reasons) the ground time of a commercial transport aircraft will be maintained relatively short, and the conventionally utilized film 4 (film covering) is not laid out for a more rapid release of water vapor out of the insulation packet 1. This diffusion process (as has been mentioned initially above) will lead to an undesired accumulation of condensate water in the known insulation packets 1 that are encased or covered with a conventional film 4. Additionally

effective disadvantages of the conventional insulation arrangement were also given initially above.

In the following, the example embodiments according to the Figures 2 and 3 will be described in greater detail. For the sake of a better understanding, the insulation arrangement according to Fig. 3 will first be considered in greater detail. An insulation structure or arrangement is contemplated, which is made up of an insulation packet 1 and a film 5, which completely encases or covers the insulation packet 1, according to the example of Fig. 1. The arrangement of this insulation structure or arrangement, which will similarly correspond to the arrangement according to Fig. 1, has been omitted from this figurative illustration. According to the two Figures 2 and 3, generally a film arrangement is contemplated, which is made up of (only) one single film 5 (encasing the insulation packet 1) or of two films 2, 3 (encasing the insulation packet 1) which are integrated into a single film 5 (intended according to the example of Fig. 3). Both film arrangements are generally realized with a film material that is permeable by gases, with which a different diffusion resistance characteristic or behavior is achieved dependent upon the diffusion direction of the total structure from the moist or damp inner space 7 to the cold outer skin 6.

With reference to the Fig. 3, the differential diffusion resistance characteristic of the film 5 is realized with a film material which provides a high diffusion resistance coefficient from the film outer wall surface to the film inner wall surface, and provides a low diffusion resistance coefficient in the opposite

diffusion direction (namely: from the film inner wall surface to the film outer wall surface). This film arrangement or structure (referring to the film 5) is worth consideration, for the fact that one may therewith enclose or cover (coat over) the outer surface area of the insulation packet 1 on all side areas with a single film 5 (encasing or covering film) of the same common material, from the point of view of a rational fabrication of the insulation arrangement. This film 5 will function in such a manner, whereby the diffusion resistance coefficient is large in a direction toward the internally located insulation packet 1 which is entirely covered or encased by the film 5. In other words, no water (vapor) can penetrate entirely to the insulation packet 1. The film 5 acts as a moisture blocker (as a vapor barrier). In the opposite direction, the film 5, however, has a different diffusion resistance coefficient, which is as small (low) as possible, so that in the given case, the accumulated water from the insulation packet 1 (from the inwardly located insulation) can easily diffuse out of the insulation packet 1 in the form of water vapor.

Returning to the Fig. 2, as mentioned, a film casing or covering is utilized, which is assembled or made up of two films 2, 3 of different types of materials. The two films 2, 3 are fixedly (and seamlessly) joined with each other along their film edges, so that one obtains a film casing or cover according to the example of the Fig. 3. Furthermore, it is a prerequisite, as already explained with regard to Fig. 1, that the insulation arrangement (according to the Fig. 2), with the film casing or cover made up of a first and a second film 2, 3, is likewise

arranged within the mentioned interspace which is enclosed by the inner trim component 12 (cabin trim paneling) and the (metal) outer skin 6 of the aircraft.

Thereby the insulation packet 1, which is fully covered or enclosed by the film 5 (made up of the two films 2, 3), will not completely line the interspace. Thereby the insulation arrangement will always be surrounded by a (certain) hollow space, due to an intended (and below described) supply of conditioned air 11.

This film (casing) that is fused at the film edges (of two films 2, 3) completely encloses the insulation packet 1 and lies thereon in such a manner so that the film surface of a first film 2 predominantly is arranged lying on the stringer 8. The film surface of a second film 3 predominantly is positioned opposite the surface of the inner trim component 12 facing toward the inner space 7. Predominantly because certain edge regions or portions of the surface, that are limited to the section(s) of the fusion of both films 2, 3, are oriented in the direction of the lengthwise extension (the extended length) of the inner trim component 12 or of the stringer 8, and from there the above mentioned conditioned air 11 will also enter into the mentioned inner space 7.

Thereby the first film 2 will lie on the extended surface area of the stringer 8, thus in the selected example, not lying on the inner trim component 12. Since the second film 3 is located free in the inner region 7 (and not lying on the inner trim component

12), the second film 3 will be surrounded most extensively by the conditioned air 11 flowing through the inner region 7.

It is also mentioned at this point, that several spacer members are arranged between the outer skin 6 and the insulation packet 1, or between the stringer edge (of the stringer 8) and the insulation packet 1. Hereby an air gap s is formed.

The first film 2 is realized with a film material that achieves a low diffusion resistance coefficient in the diffusion direction of the gas diffusing through the film wall from the film inner wall surface to the film outer wall surface. The term gas is understood to mean, as mentioned previously, relatively warm air, which is loaded with high moisture or humidity, which flows through the slits and openings of the inner trim component 12 into the inner region 7.

The second film 3 is realized with a film material that achieves a high diffusion resistance coefficient in the diffusion direction of the gas diffusing through the film wall from the film outer wall surface to the film inner wall surface.

According to all embodiments of the described insulation arrangement, the film-encased insulation packet 1 is realized with an insulation material consisting of polyphenylene sulfide (short designation: "PPS"). The latter is covered or encased by the individual film 5 embodied as a synthetic plastic film (according to the Fig. 3) or by the film arrangement, which consists of two different types of films 2, 3 (according to the Fig. 2) which are

combined together to a single film 5. Thereby the film material(s) of the film 5 (which may be combined together of two different types of film materials in a given case) (according to the film structure according to the Figures 2 and 3) realizes (realize) a differential diffusion resistance coefficient, depending on the direction of the occurring diffusion through the film wall, as described previously. Their spatial arrangement within the inner region 7 (or the interspace) is adapted, at the location of their contact surface, to the surface contour of the surface of the stringer 8 (oriented toward the inner trim component 12) or (but also) to the surface contour of the inner surface of the outer skin 6.

In closing it is summarized that the different films 2, 3, 5 (film coverings or casings) according to the Figures 2 and 3 consist of different types of film materials, so that an accumulation of condensate water in the insulation packet 1 encased by the film is excluded. A second film 3 (according to the Fig. 2) facing toward the inner region A will comprise a film material that provides a high diffusion resistance coefficient in the diffusion direction of the medium [from the film outer to the film inner (wall) surface]. That has the advantage that the air that is loaded with a (relatively) high moisture or humidity, which flows in through slits and openings from the inner region A (for example from the passenger cabin of an aircraft) into the intermediate region (into the inner region 7), cannot diffuse directly into the primary insulation (arranged close to the aircraft fuselage structure). At the area of the insulation arrangement oriented toward the outer skin 6 (as a component of

the aircraft fuselage structure), a first film 2 (according to the Fig. 2) is utilized, which is open to diffusion and which comprises a low diffusion resistance coefficient in the diffusion direction of the medium from the film inner to the film outer 5 (wall) surface.

This has the advantage, primarily during warm ground times (ground phase of an aircraft) that liquid water, which has accumulated by condensation in the insulation packet 1, can escape from the insulation packet 1 as water vapor in a (relatively) unhindered manner and therewith quickly. Thereby a drying of the insulation packet 1 is strived for. Thereby it is a prerequisite 10 that a sufficient air gap s exists between the outer skin 6 and the first film 2. The stringer 8, on which lies the primary insulation, thereby functions as a spacer member relative to the outer skin 6. Additional holder elements will serve to maintain or to enlarge if necessary the air gap region 10 between the outer skin 6 and the insulation arrangement (the film-encased insulation packet 1). Thus, two essential effects in comparison to the conventionally utilized aircraft insulation are achieved:

- 20 a) the water vapor, which can come from the inner region A (originating from the passenger cabin) into the interspace (inner region 7), is prevented from penetrating (from diffusing) into the insulation packet 1 by the second film 3 functioning as a vapor barrier;
- 25 b) the liquid water, which nonetheless collects in the insulation packet 1, may, for example, leave the insulation packet 1 in the form of water vapor through the diffusionally open first film 2, during the warm ground phase of an

aircraft. Thereby a drying of the primary insulation is supported, and therewith the accumulation of condensate water in the insulation system is prevented.

Both embodiments of the presented insulation arrangement according to the Figures 2 and 3 possess the advantage that one achieves an additional drying effect even during flight (in the cruise flight of an aircraft) with conditioned air, which one additionally supplies to the affected insulation arrangement by means of an active air conditioning device (air conditioning apparatus). This is especially because the film construction according to the Fig. 3 will ensure that the insulation packet 1 can even dry out at all. Overall, the following advantages are achieved with the presented insulation constructions:

- a) Less water vapor will enter into the insulation packet 1, so that also less condensation takes place in the insulation packet 1;
- b) Condensate water, which has once collected in the insulation packet 1, can again escape from the insulation in the form of water vapor;
- c) The insulation packet 1 can more easily be dried after all of the above;
- d) There no longer arises an accumulation of condensate water in the insulation packet 1,
- e) Because less water is present in the insulation, the operating life of the insulation arrangement or the insulation system is increased;

- f) Corresponding weight is saved in the air vehicle (for example in the aircraft), whereby the flight capacity is increased;
- g) The suggested measures may be realized without special effort. That applies also to retrofitting of air vehicles (aircraft) located in service;
- h) If, nonetheless, the utilization of a drying system is provided in the air vehicle (in the aircraft), for drying the structure, then the described insulation arrangement according to the Figures 2 and 3 may be installed to be just as effective as necessary.